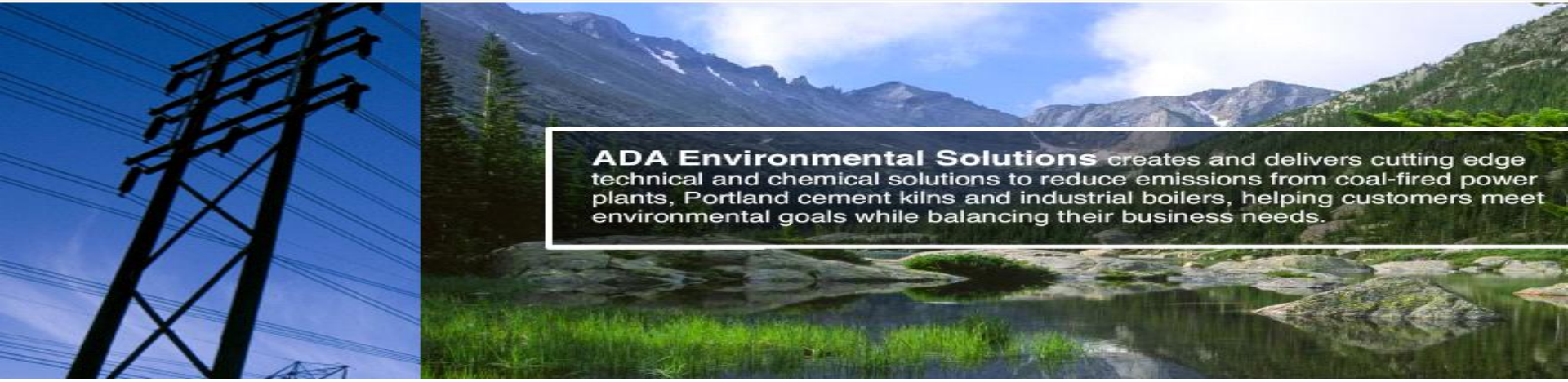
Evaluation of Solid Sorbents as a Retrofit Technology for CO_2 Capture

DE-FE0004343

NETL CO_2 Capture Technology Meeting
Pittsburgh, PA
Aug. 22, 2011



Acknowledgments

- US DOE NETL
- Stantec Consulting, Ltd.
- Shaw Energy & Chemicals, Inc.
- EPRI
- Southern Company
- Luminant

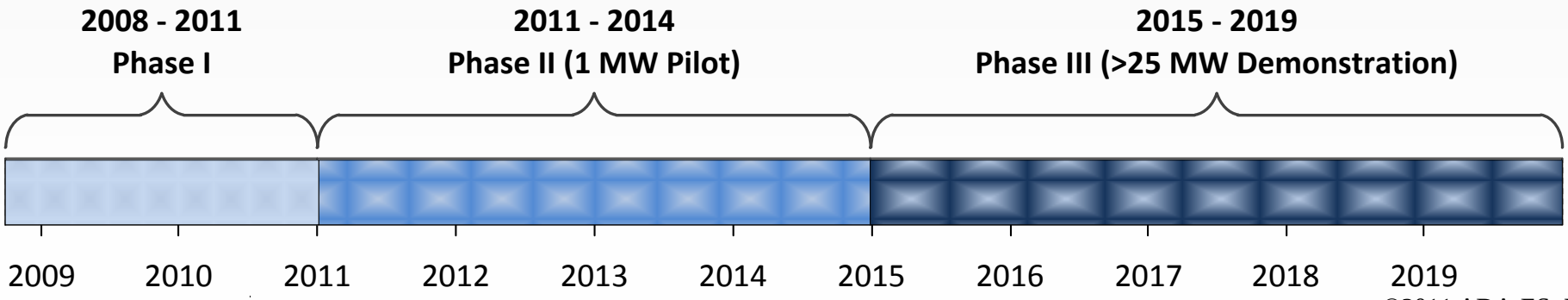
Presentation Outline

- Background on ADA CO_2 Capture Program
- Discussion of 1 MW_e Pilot Project – Scope and Schedule
- ADA Solid Sorbent Technology Status Update
- Q&A

Development Approach

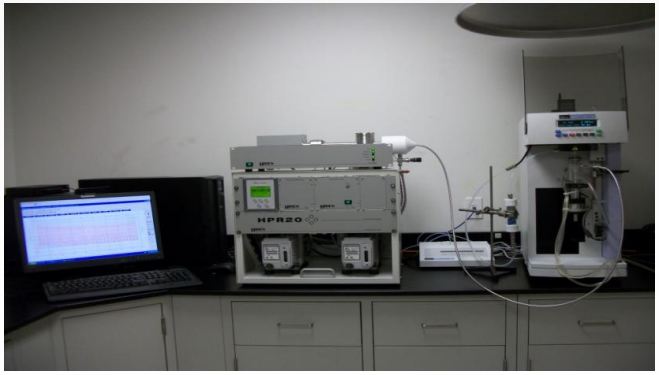
Phase I: Concept → **Phase II: Pilot Testing (1 MW)** → **Phase III: Demonstration (> 25 MW)** → **Commercial Implementation**

- Begin with the end in mind
- Identify cost drivers
- Focus R&D and execute work schedule with commercialization goal in mind



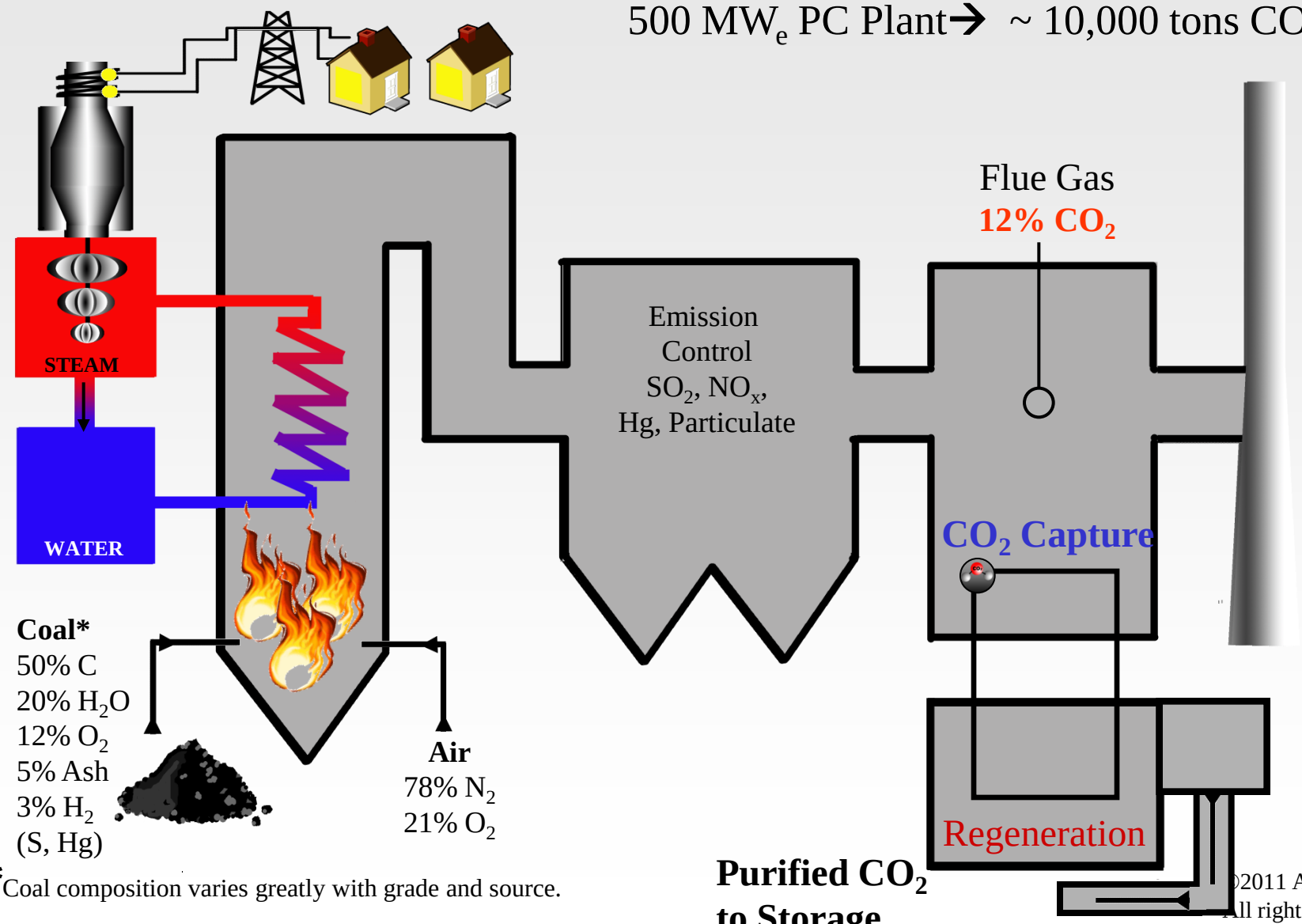
ADA CO_2 Capture Program

- **Phase I – Viability Assessment**
  - Cooperative Agreement: DE-NT0005649
    - Dual Focus: Sorbents & Process
    - 1 kW_e Test Device
- **Phase II – FEED & Pilot Testing**
  - Cooperative Agreement: DE-FE0004343
    - Sorbent Selection
    - Full-Scale Conceptual Design
    - 1 MW_e Pilot Unit
    - Techno-Economic Assessment
- **Phase III (Demonstration)**
  - Full-Scale Preliminary Design
  - Validate Design (>25 MW_e)



Post-Combustion CO_2 Capture

500 MW_e PC Plant → ~ 10,000 tons CO_2/day



*Coal composition varies greatly with grade and source.

Technology Objectives

- Reduction in energy penalty and costs associated with post-combustion CO_2 capture, compression, and sequestration
- Reduction in overall environmental impacts versus other CO_2 capture options
- Reliable operation
- Applicable to retrofit and new builds

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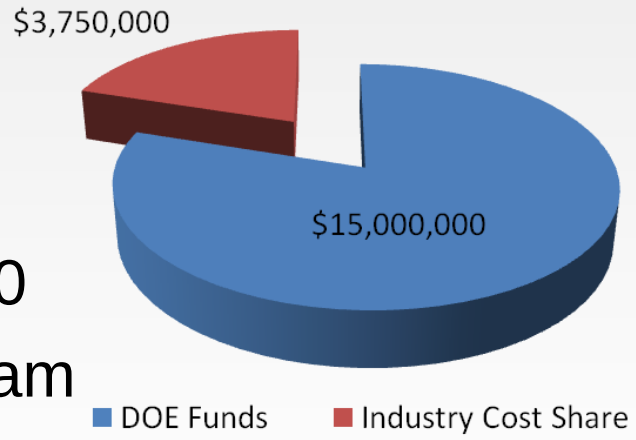
Project Objectives

- The overall objective of this funding stage is to validate solid sorbent-based post combustion CO_2 capture through slipstream pilot testing.
- Project Goals:
  - Achieve 90% CO_2 Capture
  - LCOE increase less than <35%
  - Commercial deployment by 2020
  - Generate a high purity CO_2 stream
  - Successfully scale sorbents



Federal Funding provided by the DOE National Energy Technology Laboratory's Innovations for Existing Plants Program

Project Team

- DOE – NETL
  - Project Sponsor
- ADA-ES, Inc.
  - Project Management
  - Sorbent Evaluation & Selection
  - Conceptual Process Design
  - Techno-Economic Assessment
- Shaw Energy & Chemicals, Inc.
  - Detailed Engineering Services
  - Significant Experience with Fluidized Bed Reactor Design
  - Isothermal and Adiabatic Reactors
    - Single & Multibed Reactors

- Stantec Consulting Ltd.
  - Cost Analysis
  - Plant Integration
  - Owners Engineer Perspective
- EPRI
  - Industry Cost Share
  - Independent Performance Evaluation and Techno-Economic Assessment
- Southern Company
  - Host Site
  - Cost Share
- Luminant
  - Cost Share

Key Personnel

Project Execution

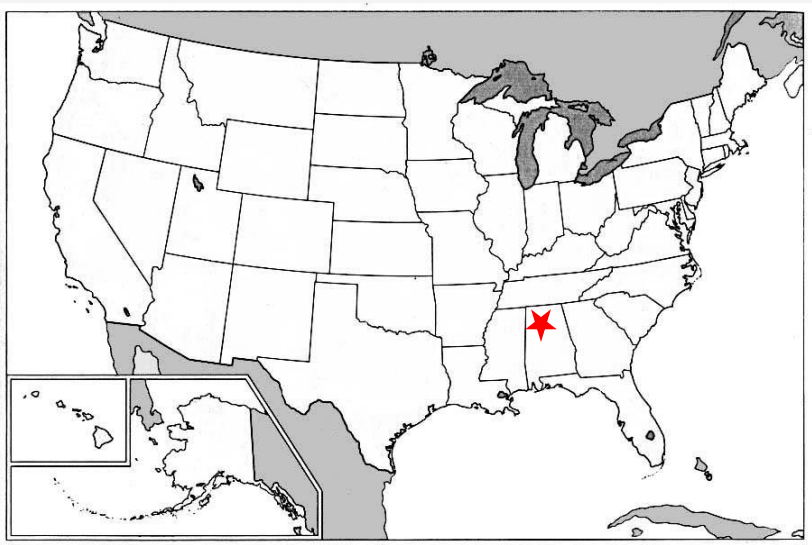
- DOE – NETL
  - Bruce Lani (Project Manager)
- ADA-ES, Inc.
  - Sharon Sjostrom (Principal Investigator)
  - Travis Starns (Project Manager)
  - Holly Krutka (Scientific Advisor)
  - Cody Wilson (Project Technical Lead)
- Shaw E&C, Inc.
  - David Adam
  - Roy Silverman
  - Robert Sandel
- Stantec Consulting Ltd.
  - Mike Richard
  - Bhurisa Thitakamol

Industry Participants

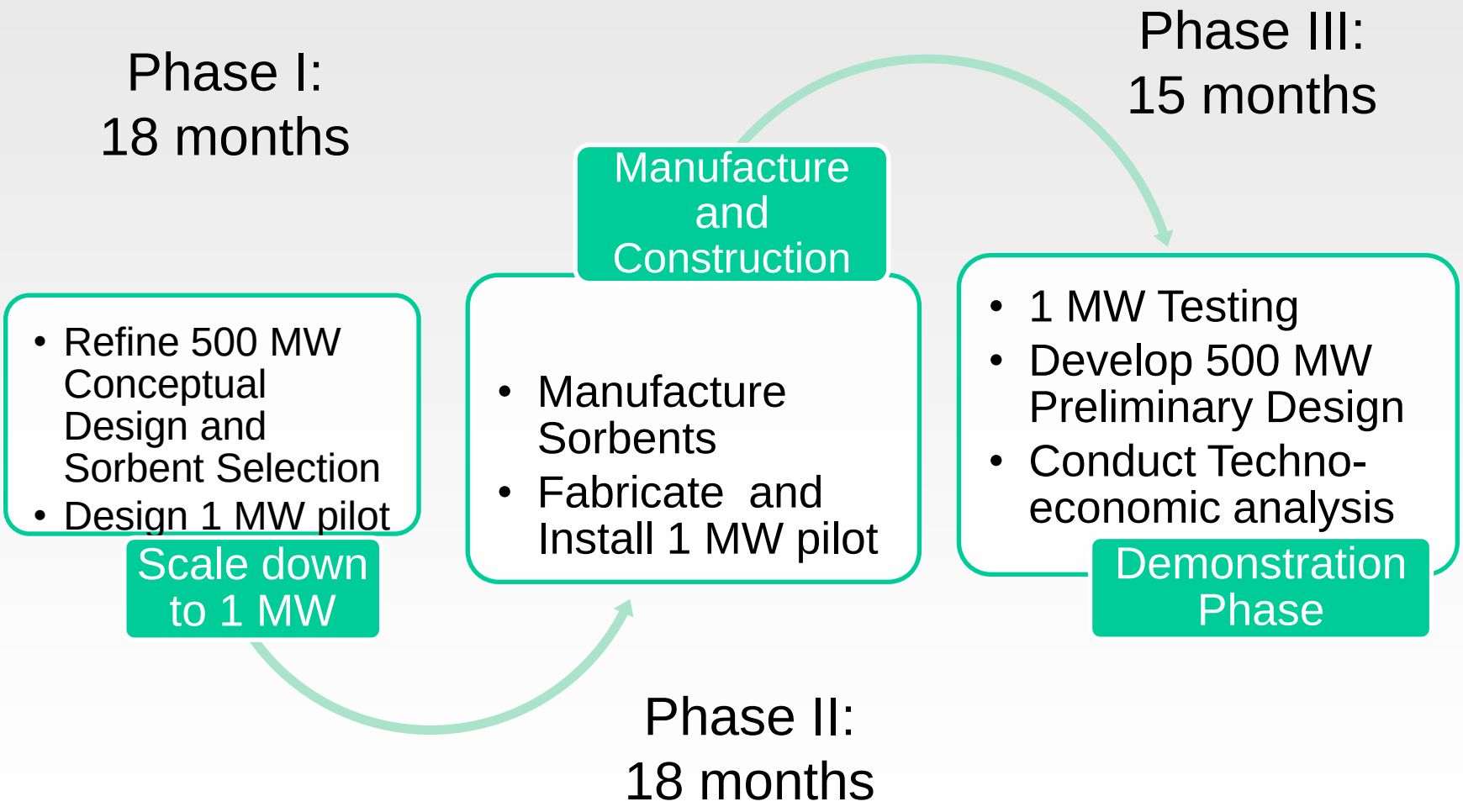
- EPRI
  - Richard Rhudy
- Southern Company
  - Michael Ivie
- Luminant
  - Rick Jeans

Host Site Information

- **Host Site:** Southern Company – Alabama Power Co. Plant Miller
  - 4 EGUs (~2,640 MW_e)
  - PRB Coal
  - WFGD
  - Pilot Located near WFGD on Unit 1
- Designed for 90% CO2 Capture
  - ~2,100 lb CO_2/hr
  - Flue Gas Flow Rate ~ 3,500 ACFM



Project Outline



1 MW Pilot Schedule Summary

Phase I

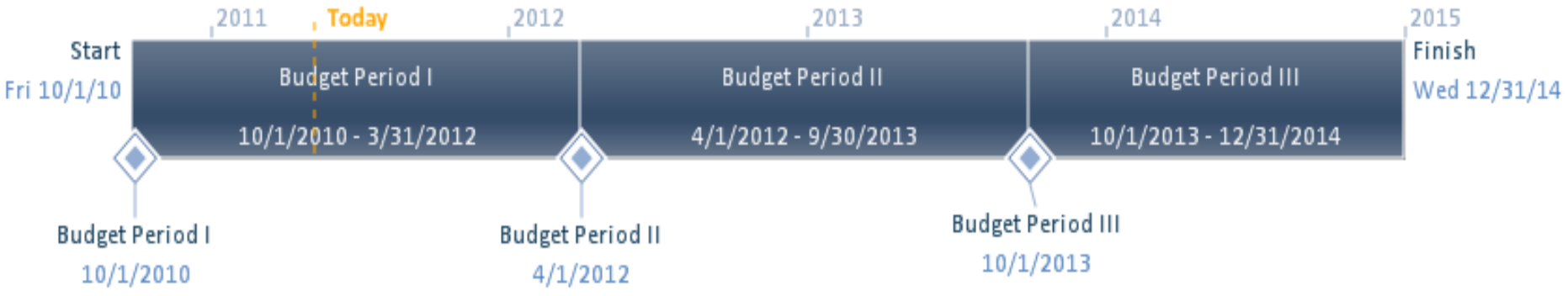
- Task 1 – Project Management Planning
- Task 2 – Full-Scale Design & Sorbent Selection
- Task 3 – Detailed Pilot Design

Phase II

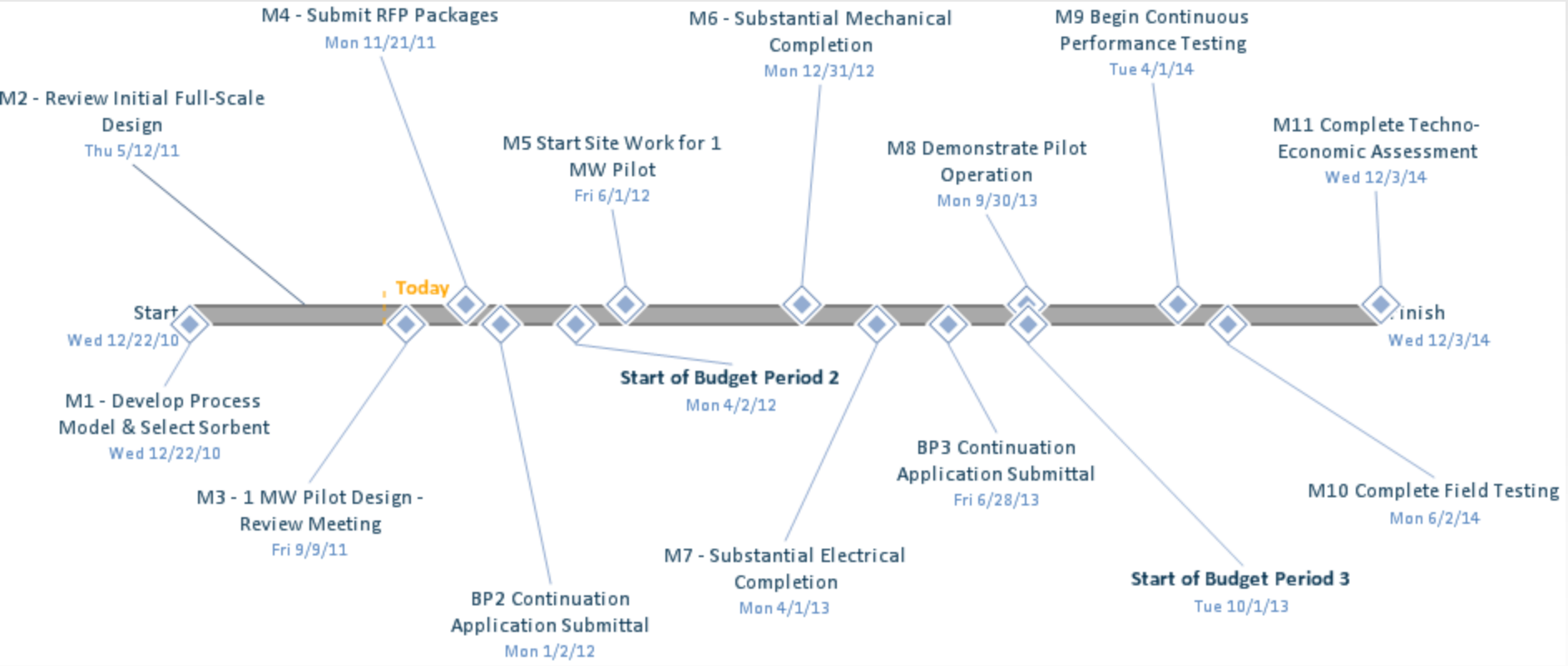
- Task 4 – Sorbent Procurement
- Task 5 – Procure & Fabricate Pilot Equipment
- Task 6 – Installation & Startup

Phase III

- Task 7 – Testing
- Task 8 – Collect Sequestration Information
- Task 9 – Final Reporting, Revise Design Specifications



Project Milestone Summary



Technology Status

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Sorbent Selection

Amines	Carbon	Zeolites	Carbonates
		X	
X	X		X
		X	X
X	X		X
X	X		

- Effect of Moisture
- Effect of Flue Gas Constituents
- Theoretical Regeneration Energy
  - Theoretical RE
  - Working Capacity
  - $\Delta T_{ads.-regen.}$
- Cyclic Stability
- Rate of Reaction (qualitative)

Promising Materials: Supported Amines

Four supported amine sorbents produced in 600 lb quantities for 1 kW pilot testing.

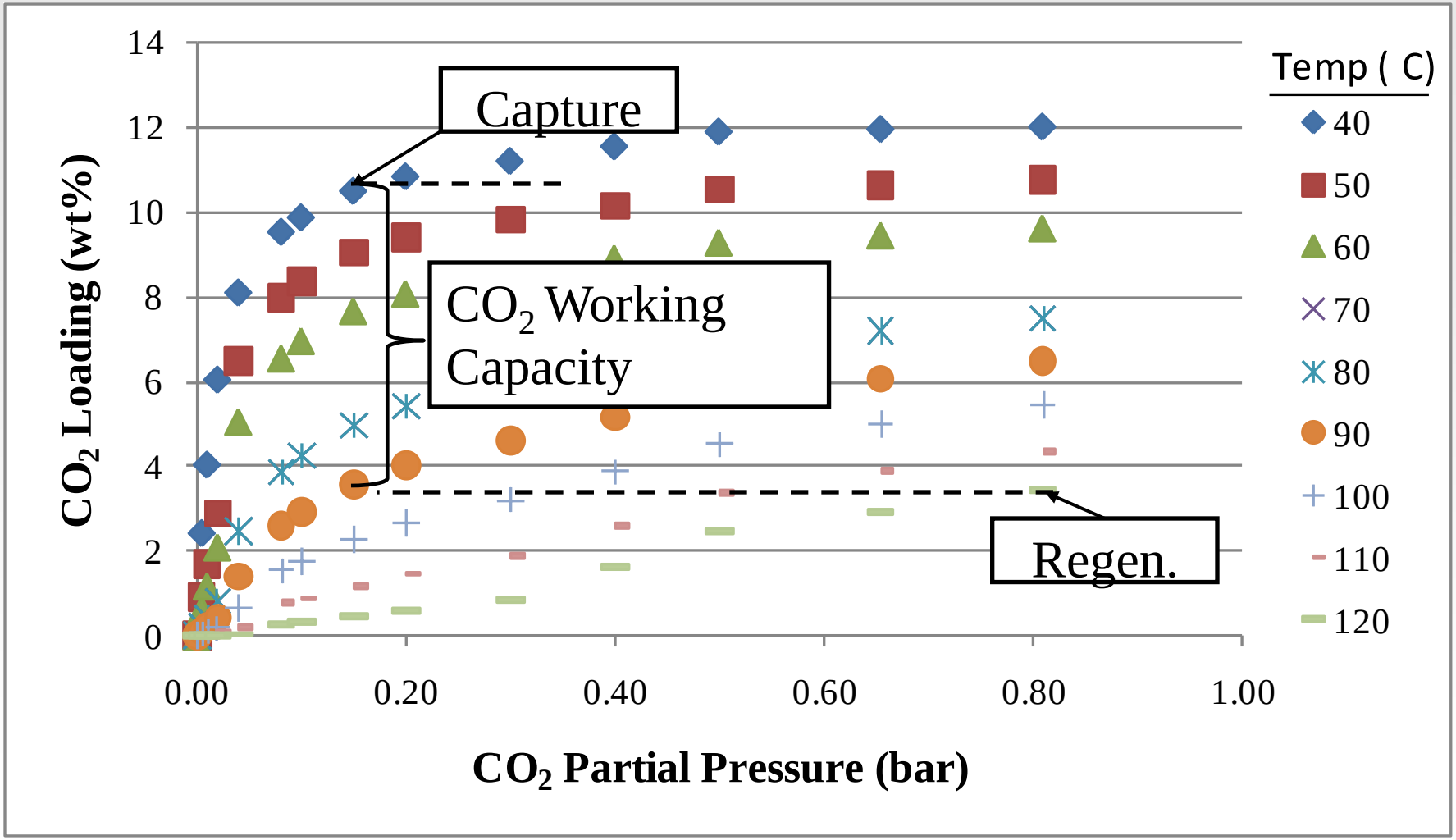
Promising Supported Amine Sorbents

- Sorbent BN
  - Advantages
    - Kinetics
    - Higher working CO_2 capacity
    - Stability
    - Commercially available
    - Experience with changing particle size
    - Potential regeneration after the formation of heat stable salts
  - Concerns
    - Particle size needs to be adjusted for process design
    - Moisture uptake

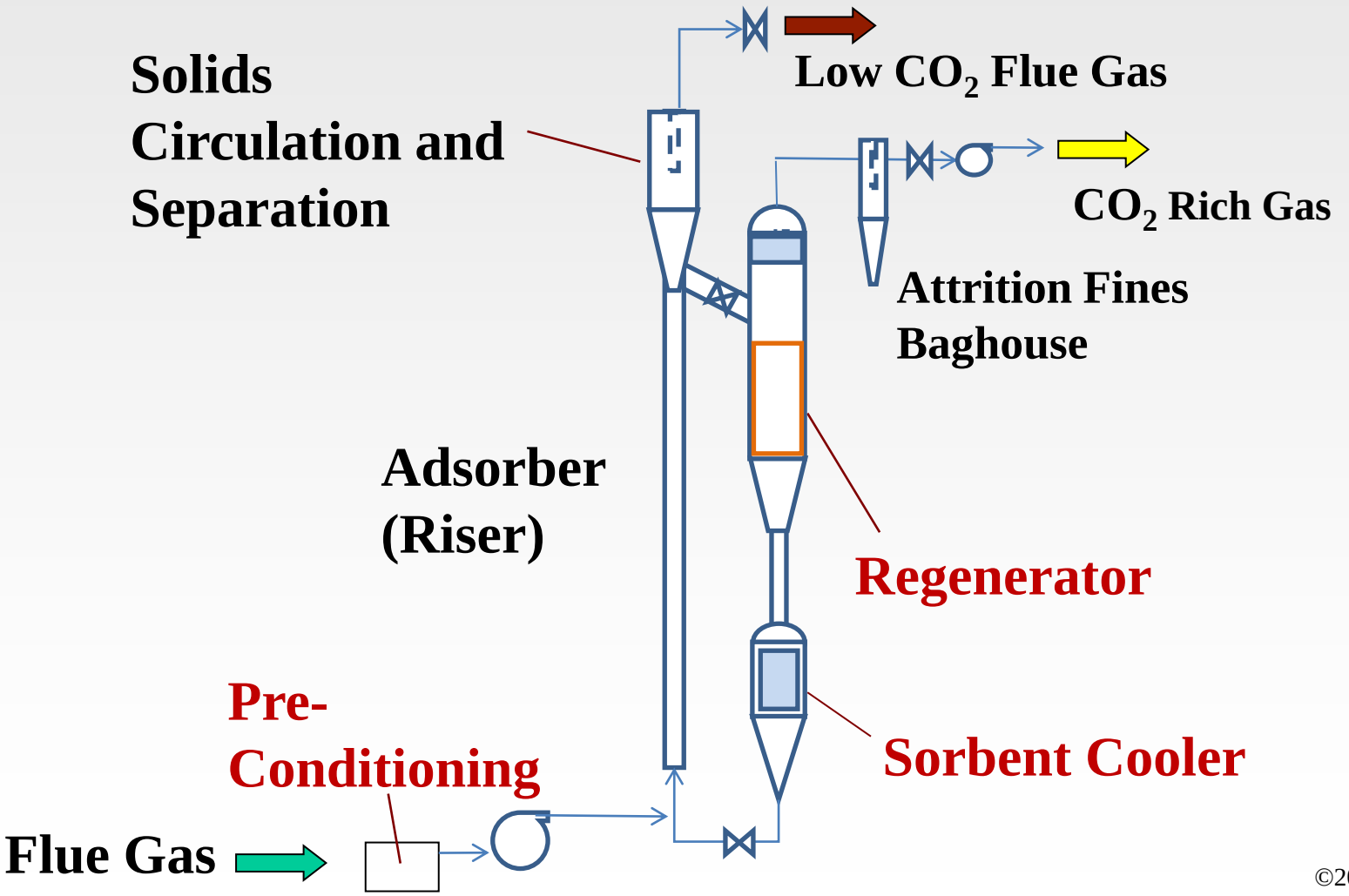
- Sorbent CE
  - Advantages
    - Extremely high total CO_2 capacity
    - Stability
    - Physical properties - fluidized beds
  - Concerns
    - Regeneration requires lower partial pressure for adequate working capacity
    - Kinetics
    - Moisture and condensation

Sorbent BN selected for use in 1 MW Pilot

TGA Generated Sorbent BN Isotherms

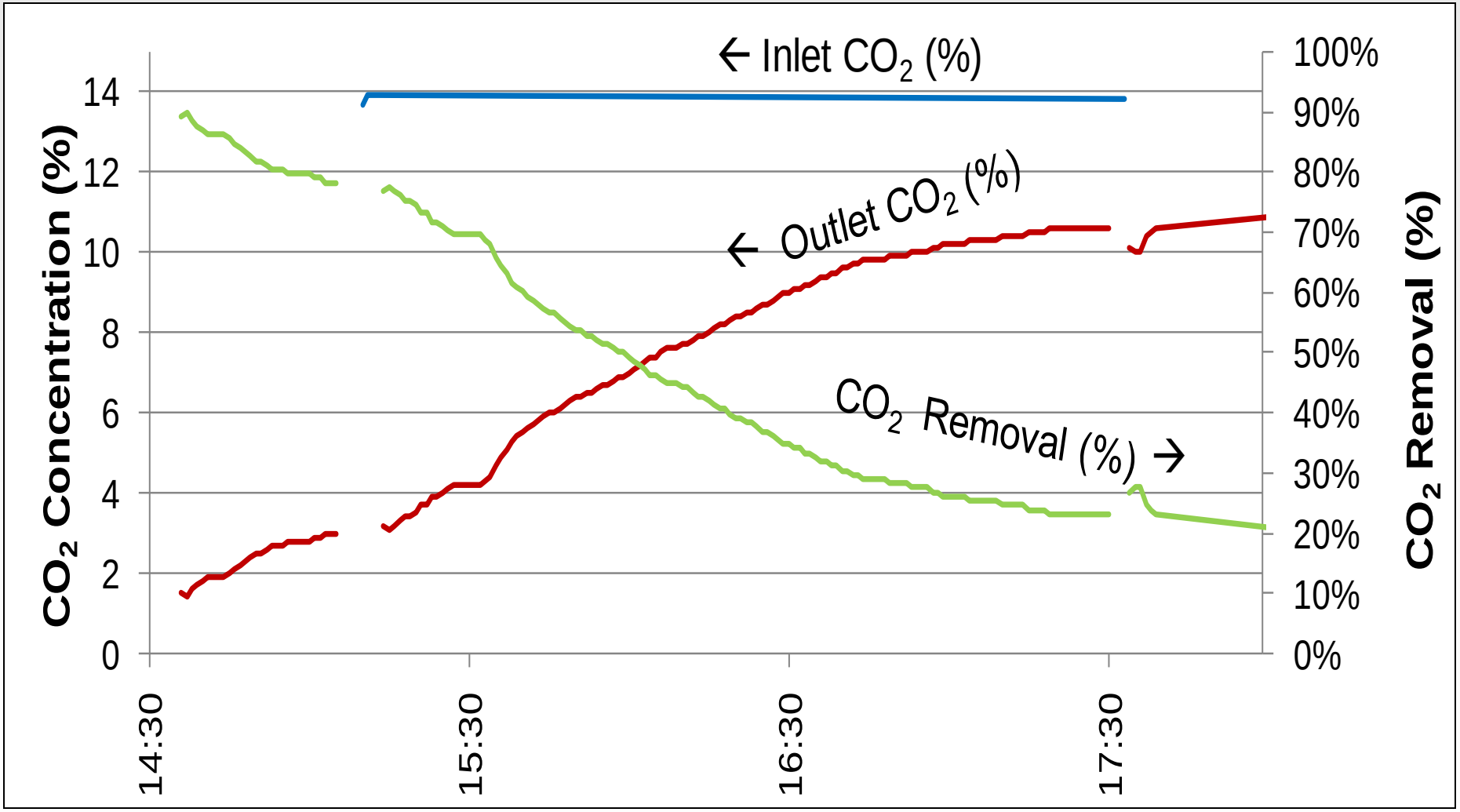


1kW$_e$ Test Device

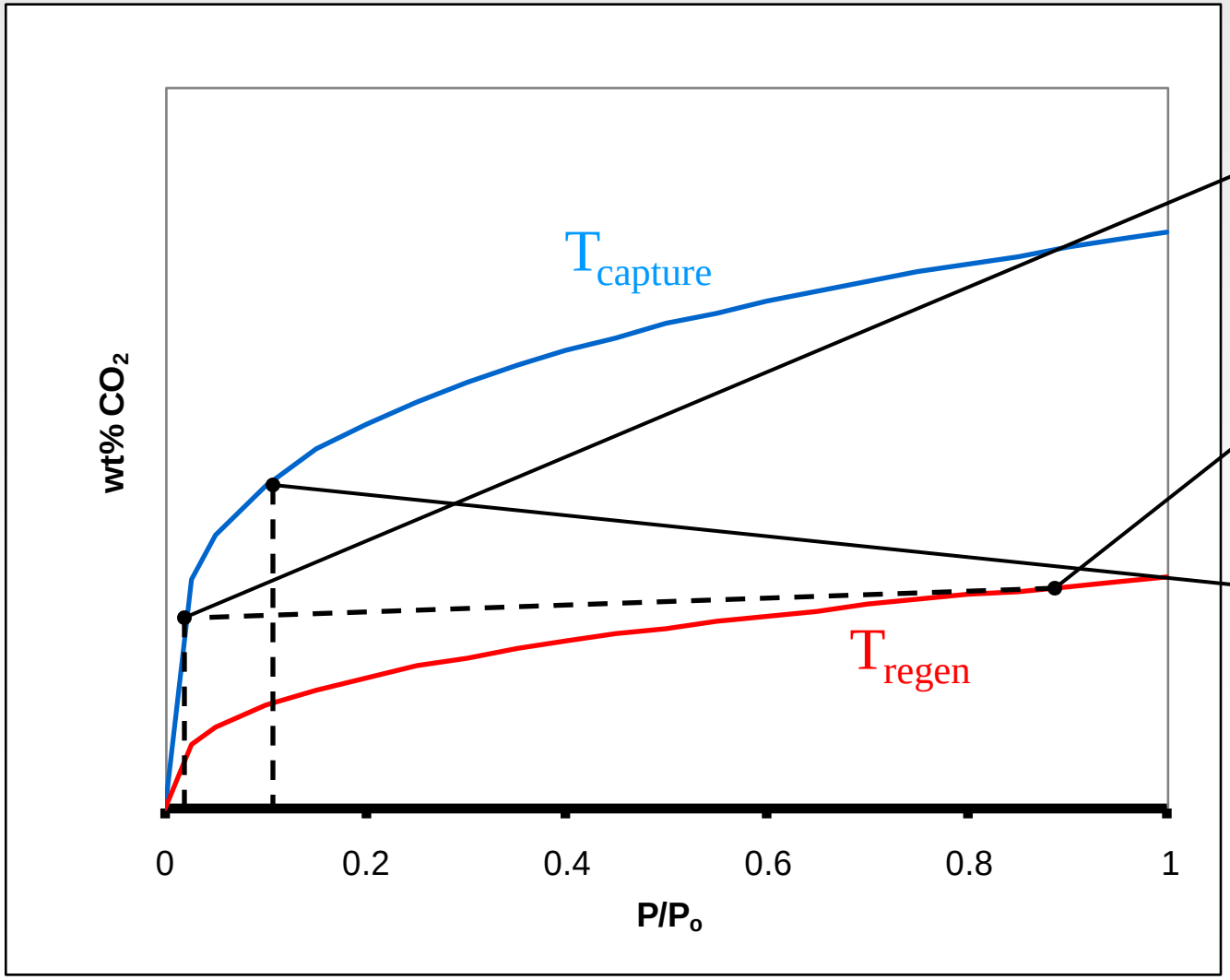


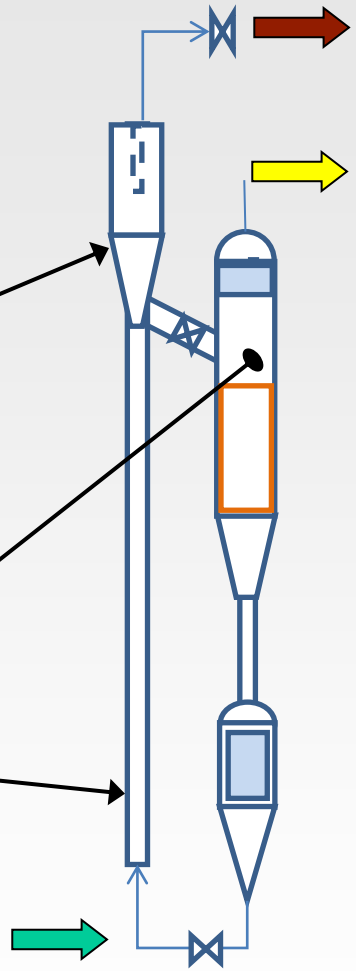
Process concept provided by Southern Company Services

Continuous Testing – 1 kW_e Test Device



Challenge with Co-Current Process Design

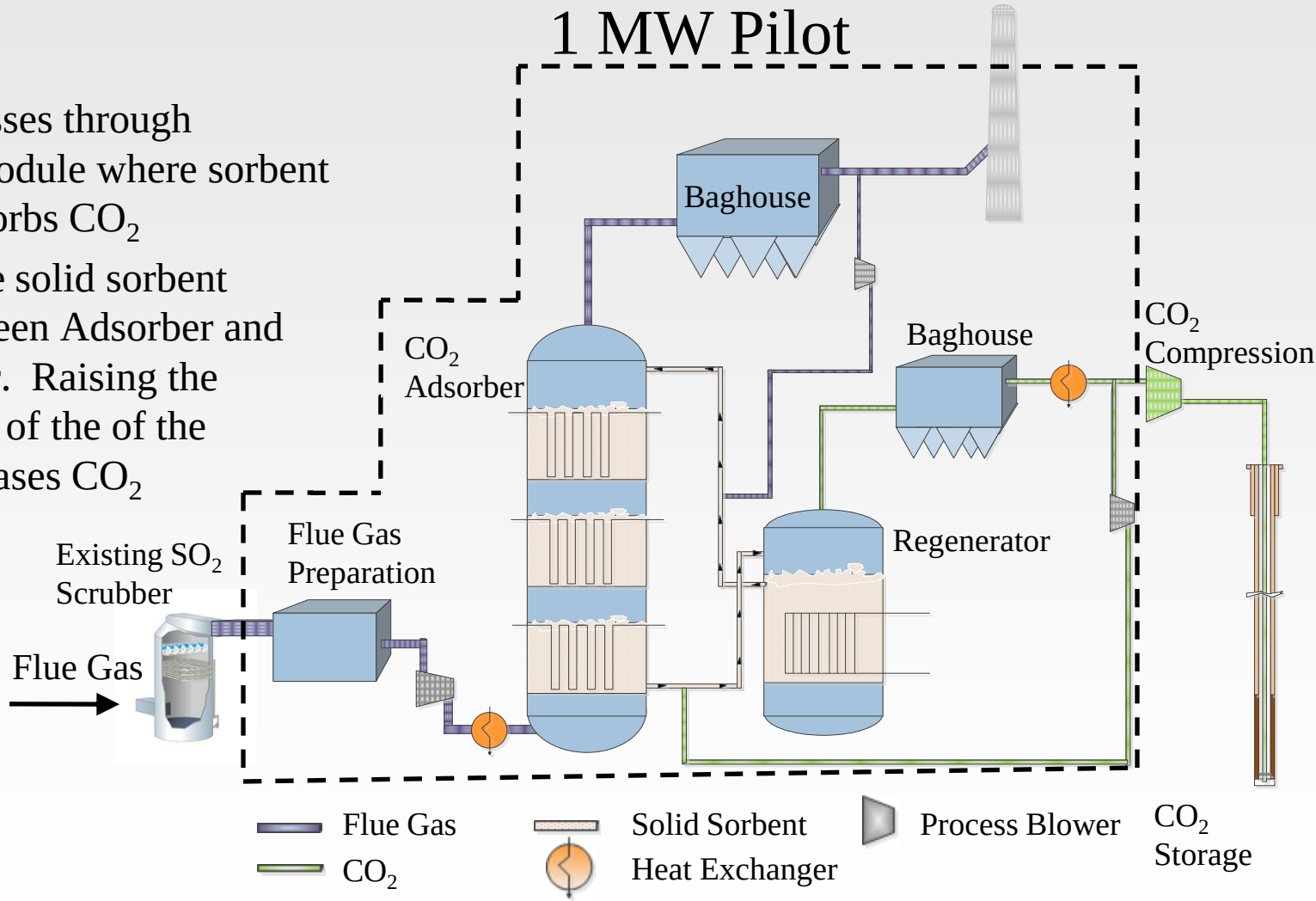




ADA Solid Sorbent CO2 Removal Process

Principal

- Flue gas passes through Adsorber module where sorbent particle adsorbs CO_2
- Regenerable solid sorbent cycles between Adsorber and Regenerator. Raising the temperature of the of the sorbent releases CO_2



Next Steps: Heat Integration & Optimization

1 MW Pilot: Focus Areas

- Sorbent attrition
  - Currently using data for FCC catalysts
  - Physical & chemical
- Volatile emissions
- Validate regeneration energy requirement
- Measure actual adsorption temperatures to maintain 90% CO_2 capture
- CO_2 purity
- Sorbent regeneration time

- Process effect from flue gas constituents
  - Presence of moisture
- Optimize process variables
  - Temperatures
  - Sorbent circulation rates

Creating a Future with Cleaner Coal

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Scientific Advisor: Holly Krutka
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Project Technical Lead: Cody Wilson
codyw@adaes.com

Task Summary

Phase I	Phase II	Phase III
• Task 1 – Project Management Planning • Task 2 – Refine Full-Scale Design and Sorbent Selection • Task 3 – Design Pilot Equipment	• Task 1 – Project Management Planning • Task 4 – Procure & Manufacture Sorbents • Task 5 – Procure and Construct Pilot Scale Equipment • Task 6 – Install/Startup Pilot Scale Equipment	• Task 1 – Project Management Planning • Task 7 – Pilot Scale Operation & Evaluation • Task 8 – Collect Compression and Sequestration Information • Task 9 Prepare Commercial Conceptual Design and Economics
(10/1/2010 – 3/31/2012)	(4/1/2012 – 9/30/2013)	(10/1/2013 – 12/31/2014)